CONSTRUCTION STANDARD SPECIFICATION

SECTION 13100

LIGHTNING PROTECTION

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LIGHTNING PROTECTION

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes furnishing and installing a complete lightning protection system, or modifications to an existing lightning protection system, in accordance with the standards and codes specified and as shown on the Sandia National Laboratories (SNL) furnished drawings. An integral system is required, consisting of air terminals mounted directly on the structure to be protected.

B. When specifically requested in the contract documents, shop drawings showing the complete installation shall be furnished, as part of the scope of work, in lieu of the SNL drawings. Drawings shall be created using Intergraph Microstation format according to SNL CADD standards.

C. This specification is applicable to structures (including buildings) handling or storing explosives, flammable vapors and gases, or liquids that can give off flammable vapors, radioactive material and other hazardous materials.

D. Periodic maintenance and testing of an existing lightning protection system are not covered by this specification.

E. The lightning protection work shall be coordinated with electrical grounding requirements and supplemental surge protection of electrical service(s), telephone service, antenna cables, etc.

F. Related Sections - Refer to the following sections for related work:

1. Section 02200, "Earthwork" for excavation and backfilling for counterpoise and buried conductors.
2. Section 16001, "Electrical Work".
3. Section 16289, “Surge Protection Devices”

G. Alternate lightning protection design approaches such as "dissipation array" and "early streamer" systems are not acceptable.

H. Mast/overhead shield wire (catenary) systems shall be installed only when specifically mandated in contract documents. (Note: Normally these will only be installed with structures containing explosive or flammable materials.)

1.02 REFERENCES

Comply with the following applicable standards and codes:

A. All structures:

1. Department of Energy (DOE)

a. DOE O 420.1A – Facility Safety

b. DOE G 420.1-1 – Nonreactor Nuclear Safety Design Criteria and Explosive Safety Criteria Guide

2. National Fire Protection Association (NFPA)

a. NFPA 70 - National Electrical Code (NEC)

b. NFPA 780 - Lightning Protection Code

3. Underwriters Laboratories Inc. (UL)

a. UL 96 - Standard for Lightning Protection Components

b. UL 96A - Standard for Installation Requirements for Lightning Protection Systems

c. UL 467 - Standard for Electrical Grounding and Bonding Equipment

B. Additional requirements for structures containing explosives:

1. U.S. Army

a. AMC-R 385-100, Chapter 8, Lightning Protection - Army Material Command "Safety Manual".

2. Department of Defense (DOD)

a. DOD 6055.9 - STD, Chapter 7, Lightning Protection - Ammunition and Explosive Safety Standards.

3. Department of Energy (DOE)

a. DOE M 440.1-1 - DOE Explosives Safety Manual.

C. Additional requirements for the handling of flammable or combustible liquids, combustible solids and dusts, and manufacture of organic coatings:

1. International Fire Code Institute (IFCI)

a. Uniform Fire Code, Article 50.

D. Additional requirements for Telecommunications, Alarm, and Automatic Data Processing Centers, and Radio Repeater Stations:

1. Department of Defense (DOD)

    a. MIL-HDBK-419: Military Handbook - Grounding, Bonding, and Shielding for Electronic Equipments and Facilities

2. Department of Commerce

    a. FIPS PUB 94: Federal Information Processing Standards Publication "Guideline on Electrical Power for ADP Installations".

E. Where differences arise between the specified standards and codes, the installation shall comply with the more rigorous and demanding requirements, whether or not shown on the drawings. Similarly, comply with the more stringent requirements of this specification and drawings.

1.03 SYSTEM DESCRIPTION

A. The extent of lightning protection work is indicated and detailed on drawings (if furnished), and by requirements of this specification. The types of lightning protection system components specified include the following:

1. Conductors
2. Air terminals
3. Connectors
4. Splicers
5. Ground rods
6. Bonding plates

B. New Construction: Protect entire building (or structure) including roof projections, chimneys, exhaust stacks, vents, antennas, roof-mounted equipment, ladders, cranes, cooling towers and equipment or structures adjacent to the building.

C. Existing Buildings and Structures: Modify existing lightning protection system so additions to roof mounted equipment, etc., are protected. For equipment removals and similar modifications ensure that main roof conductors are continuous and have at least two horizontal and downward paths to connections at the counterpoise.

1.04 SUBMITTALS

A. General: Submit the following in accordance with the conditions of the Contract and Section 01300, "Descriptive Submittals".

B. Product data: Submit product data for each component. Include data for roof adhesive when used. Where applicable, also include recommended method(s) of installing air terminals, conductors, etc., to single-ply membrane roofs. (Note: This applies to new roofs. For existing roofs follow SNL procedures.)

C. Shop Drawings (if required by contract documents): Submit scaled drawings of the lightning protection system and components for approval. Show conductor routing

and accessories layouts including accessible ground wells and ground rods, counterpoise, air terminals, splicers, fasteners and connectors.

D. UL Certification: Upon completing installation, provide Sandia a UL "Letter of Findings".

E. Where required by Section 3.03, submit certified test reports showing actual ground resistance measurements and bonding resistance measurements.

1.05 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of lightning protection equipment, of types and sizes required, whose products have been in use for not less than 3 years. All components of the lightning protection systems shall be new and suitable for the application in accordance with the specified standards and shall be UL listed and labeled.

B. Installer’s Qualifications: A firm with at least 3 years of successful installation experience on projects with lightning protection work similar to that required for this project. The installer shall be a current UL Listed company.

C. Underwriters' Laboratories, Inc. Certification

1. All structures with lightning protection systems require a UL "Letter of Findings".

D. Field Measurements

1. Resistance-to-ground measurement shall be made using the "three point" or "fall of potential" method.

2. Measurements shall be taken for all new lightning protection systems at new or existing structures containing explosives or flammable materials to confirm that the resistance-to-ground is not greater than 10 ohms. For other installations the contract documents will indicate when these measurements are required.

E. Sandia/Underwriters Inc. Agreement

Sandia specifications, per 2.01, require that copper shall be used. In 2002 UL issued a revision to UL96A. That revision clarified which metals were code compatible with aluminum and which were compatible with copper. Sandia discovered that the UL revised requirements call for aluminum fittings and conductors on new installations. This placed lightning protection design and installation firms in an awkward position. U.L. certified design and Installation contractors could not meet this specification and still comply with UL standards. The Underwriters Laboratories (UL) and Sandia have reached an agreement allowing Sandia to use all copper lighting protection systems. Refer to attachment A for the U.L. agreement letter.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Handle lightning protection components carefully to avoid damage. Do not install damaged components; replace and remove damaged units from project site. Store components in original wrappings and protect from dirt, weather and construction work traffic.

1.07 WARRANTY

A. Lightning protection equipment shall be guaranteed against defective design, materials, and workmanship for the full warranty time, which is standard with the manufacturer or supplier, but in no case less than one year from the date of system acceptance.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Only copper conductors, air terminals, etc., and suitable hardware shall be used.

B. For all structures containing explosives or flammable materials, irregardless of height, use Class II materials, including minimum requirements specified below.

C. The following material types, sizes, etc., shall be utilized except as noted otherwise on the contract documents:

1. Conductors: Conductors shall be bare stranded copper in the following sizes:

a. Underground counterpoise (ground loop) -- #4/0 AWG minimum (107.20. mm^2), Class B stranding.

b. Main conductors (roof level between air terminals and down leads):

(1) Class I Materials - 24 strands of 14 gauge (2.08 mm^2) braided smooth twist; 98,500 circular mils (50 mm^2); 320 lbs. per 1000 ft. (145.2 kg per 304.8 meters) or larger.

(2) Class II Materials -- 28 strands of 0.0689 inches (0.175 cm) diameter, copper wire, rope lay, 131,500 circular mils (66.6 mm^2); 420 lbs. per 1000 ft. (190.5 kg per 304.8 meters) or larger.

c. Bonding conductors (including solid and flexible strips of equivalent circular mil size) for large roof mounted equipment (HVAC units, etc.) and miscellaneous metallic items: Use same conductors as specified in item “b” above.

(1) Bonding conductors for items such as roof drains, windows, etc., that are not generally subject to physical damage, may be of smaller size than stated above but not less than the equivalent UL.

(2) Lead coated conductors shall be used in atmospheres corrosive to copper.

D. Air Terminals (Both Class I and Class II): Air terminals shall be solid copper, minimum 1/2-inch (12.7 mm) diameter, nickel plated tip, and a minimum of 24-inches (60 cm) long. For corrosive locations (e.g. smoke stacks) use stainless steel air terminals. Air terminals for single-ply roof mounting shall have bases especially designed for this application (see Section 3.02.A.2).

E. Ground Rods: Ground rod material shall be copper-clad steel or solid copper. Ground rods shall be not less than 3/4" (19.05 mm) in diameter and not less than 10 ft. (3.05 m) long.

F. Connectors and Fittings:

1. Use only heavy-duty bronze connectors, splicers, bonding plates, etc., with maximum available contact surface between this hardware and each conductor or equipment. If heavy-duty connectors and fittings are not available from supplier submit alternates for SNL approval before installation.

2. Each conductor shall be held in place with at least two hex head bolts.

3. Bonding plates shall have a minimum of 8 sq. inch (412.90 cm^2) of contact surface.

4. For pipes, railings, fence post, etc. up to approximately 4 1/2" (11.43 cm) in diameter use heavy-duty bronze pipe clamps, where available, in lieu of bonding straps.

5. All main size connections shall contact cable for a length of 1.5" (3.81 cm) minimum.

6. Split-bolt type connectors shall not be used.

7. Connections below grade and all inaccessible splices shall use the exothermic welding process. Where shown on the drawings, exothermic welds shall be used above grade, particular for connections to building steel and similar items.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine surfaces and conditions affecting performance of the lightning protection system. Do not proceed with installation until unsatisfactory conditions have been corrected. Contact the Sandia Delegated Representative (SDR) for resolution of unsatisfactory conditions.

3.02 INSTALLATION

A. Ordinary Structures (Not associated with explosive or flammable materials, etc.).

1. Install lightning protection systems, including modifications to existing systems, as indicated on the drawings and according to manufacturer's written instructions, UL 96A, and NFPA 780 and other referenced codes and standards.

2. Install air terminals as high as possible and such that the zone of protection is at least 10 inches (25 cm) higher than the structure, equipment, etc., that they are protecting. For air terminals on single-ply roofing use adhesive recommended by manufacturer of air terminals and approved by manufacturer of roofing material. Comply with adhesive manufacturer's installation instructions. (This applies to new roofs. For existing roofs follow SNL procedures.)

3. A ground loop (counterpoise) and ground rods shall be installed for all new structures. This loop and top of ground rods shall be installed at least 2.5 ft. (0.762 m) deep in soil and between 3 ft. (0.91 m) and 8 ft. (2.44 m) from exterior of building or structure. Install marking tape 1 ft. (0.30 m) below grade above ground loop. Ground rods shall be installed at all corners of the building or structure and around the building or structure with maximum spacing of 35 ft. (10.67m) between ground rods. The separation between any two ground rods shall be at least the length of the longer rod. To reduce resistance-to-ground, unless shown otherwise on drawings, connect reinforcing steel of the concrete slab in contact with soil (or vertical wall when a basement is provided) to the ground loop at each corner of the structure and at intervals of approximately 35 feet (10.67 m) around the structure with a main size conductor. Use exothermic weld connections for connecting reinforcing steel together and to the ground loop.

4. For concrete structures, bond reinforcing steel to down conductors and roof conductors as required by NFPA 780 and UL. 96A.

5. Bond all metallic underground services entering the structure, and other underground and above ground metallic objects within 25 ft. (7.62 m) of the structure, together with the ground loop using the same size of conductor as the ground loop.

6. Except specifically noted on the contract documents do not utilize structural steel framework as a main conductor. Make the steel framework of buildings or structures electrically continuous by bolting, riveting, or welding the steel frame, unless a specific method is noted on the drawing. Where a water system enters the building, connect the structural steel framework and the water system at the point of entrance by a ground connector. Secure connections to pipes by means of ground clamps with lugs. Secure connections to structural framework by exothermic welding. Secure all connections between bottom of columns and ground connections to ground loop from not less than one-half of all the columns distributed equally around the perimeter of the structure. When no water system enters the structure, extend ground connections from all steel columns.

7. For externally routed down conductors protect each conductor from possible damage with an 8 ft. (2.44 m) long wooden or PVC pipe protector above grade level. Where conductors are run through metal pipe, or otherwise protected by metal strips, the conductor shall be bonded to each end of the metal pipe, etc.

8. Bond ladders at top and bottom and bond handrails at each end but not more than 50 feet (15.24 m) apart. Protect handrails, ladders, HVAC equipment, etc., with air terminals and main conductors when metal thickness is less than 3/16 inch (4.76 mm). Attach lightning protection components to HVAC equipment and roof and wall metallic items with sheet metal screws. Apply sealant to prevent ingress of moisture around screws. Placement of air terminals on roof equipment is identical to that of roof (e.g. air terminals must be within 2 ft, 0.61 m, of corner of equipment). Connect guy wire supports for exhaust stacks and poles to the lightning protection system at their lower ends.

9. All reinforcing steel in roofs, walls, floors, and slabs of building or structure shall be tied tightly together with metal ties such that they are in electrical contact at least every 3 feet (0.91 m) in each direction. Also each level of reinforcing steel at roofs, floors, and slabs shall be similarly tied to the reinforcing steel of exterior walls at least every 3 feet (0.91 m) along the length of the wall.

10. Concealment: Do not conceal any portion of the lightning protection system, including counterpoise and reinforcing steel bonding, until approved by the SDR or UL Inspector.

B. Structures Containing Explosives, Flammable Materials

1. All foregoing installation requirements for ordinary structures also applies to structures containing explosives, flammable materials, etc., except if modified by the more stringent requirements of the standards and codes specified in Section 1.02B and C. The term structure also applies to vessels, tanks or other containers in which these materials are contained.

2. Install lightning protection systems, including modifications to existing systems as indicated on the drawings and according to manufacturer's written instructions, UL 96A, NFPA 780 and other referenced codes and standards. In particular, comply with the specific requirements of the standards and codes specified in Section 1.02 B and C and NFPA 780, Appendix K, "Protection of Structures Housing Explosive Materials". A ground loop (counterpoise) is required for all installations.

3. Igloo-Type Magazines: In earth-covered reinforced concrete, igloo-type magazines, make the reinforcing steel electrically continuous by welding unless a specific method is noted on the drawings. Install a ground loop (counterpoise) with ground rods and connect the ground loop to the horizontal reinforcing rods below the floor line of the wall system as shown on the drawings but not less than two diagonally opposite connections. Make the

steel door frame and access panels electrically continuous with the reinforcing steel. Connect the steel door to the steel frame by means of a flexible copper strap or cable equivalent to #2 AWG (33.62 mm^2) conductor or greater. (Note: These requirements also apply to above ground "Explosive Storage Magazine Structures".)

3.03 FIELD QUALITY CONTROL

A. Upon completion of installation test resistance-to-ground with resistance tester as required by Section 3.03D. The results of this test shall be documented in a certified test report and given to the (SDR) for review. If required, and at the direction of the SDR, take appropriate action to reduce the resistance to an acceptable level by driving additional ground rods and other methods as directed by the SDR. Then retest to demonstrate compliance and resubmit certified test report. All tests shall be conducted by individuals who are qualified by the test equipment manufacturer.

B. The resistance-to-ground for structures containing explosive or flammable materials shall not be more than ten (10) ohms.

C. To facilitate ground resistance testing, ground rod test wells shall be installed as shown on the drawings. Install a ground test well at each corner of the counterpoise for all new structures, unless indicated otherwise on drawings.

D. The "fall of potential" or "three point" method shall be utilized for testing of the ground electrode system. Typical test instruments include the "ground ohmeter", and Biddle or Meggar ground tester, and must be capable of measuring 10 ohms plus or minus 10%. This method utilizes three electrodes for testing, one electrode being the ground rod under test, and two test probes set in a straight line out from the ground rod to be tested. The outer most test probe is fixed during test (typically not less than two times the width of the counterpoise) while the second ground is moved at equal intervals for at least three measurements.

E. For all new structures and major modifications to existing structures containing explosives and flammable materials, perform bonding resistance tests to confirm that the resistance of any object bonded to the lightning protection system does not exceed one (1) ohm (see NFPA 780, Appendix K). Use only test equipment specifically designed for this purpose that must be capable of measuring one (1) ohm plus or minus ten (10) percent. Submit certified test report. Take appropriate corrective action, where necessary, to reduce all bonding resistances below one (1) ohm and re-submit certified test report to show compliance.

F. Provide service of manufacturer's representative to train Owner's building maintenance personnel in procedures for testing and determining resistance-to-ground values of lightning protection system.

G. Provide the services of Underwriters Laboratories, Inc., to perform inspections for new structures or as required on the contract documents for existing structures.

PART 4 – ATTACHMENTS

A. Underwriters Laboratory Inc. Lightning Protection Services For SNL letter.

END OF SECTION

ATTACHMENT A

Underwriters Laboratories Inc.®

September 5, 2003

Sandia National Laboratory

Attention: Mr. John Thayer

Subject: **UL Lightning Protection Services For SNL**

Dear Mr. Thayer:

This letter is in response to our meeting at the Sandia National Laboratories on September 4, 2003.

Based on an agreement between UL and SNL, all Lightning Protection System installations shall be constructed of copper unless specified otherwise by SNL and/or UL.

We also attached a brief overview of the Master Label Program for your reference.

Please feel free to contact us if you have any further questions or comments.

Paris Hudspeth
Lightning Protection Manager
Field Services
Telephone No.: 303-745-5020